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# Laboratory report

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For your personal information

number : ECO 8001 date : 18-01-1980

title : EQUIVALENT CIRCUIT DIAGRAM OF THE TRANSISTORS BFR90, BFR91, BFR96 AND BFQ33

author : A.H. Hilbers

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central application laboratory CAB
eindhoven - the netherlands

number : ECO 8001
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project : 6967
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title EQUIVALENT CIRCUIT DIAGRAM OF THE TRANSISTORS BFR90 BFR91, BFR96 AND BFQ 33.

author A.H. Hilbers

## ABSTRACT

For the above mentioned transistor types equivalent circuit diagrams have been given. They hold for the VHF/UHF range in the recommended operating point. The results are based on measured S-parameters and the maximum inaccuracy is between 6 and 10%.

Appr. R.A. Pölzl

| | | | | | | |
|---|---|---|---|---|---|---|
| Advies Octrooi d.d.<br>1980-01-31 | X<br>AV | GV | | B...... | | BL |
| Opgave Mamo d.d.<br>1980-01-31 | X<br>AV | X<br>GV | X<br>SP | B...... | | BL |
| Datum:<br>1980-01-22 | Mamo | | | | | |

## 1. INTRODUCTION

In the publications of the above mentioned transistor types S-parameters have been given for a range of frequencies. However some users prefer an equivalent circuit diagram, e.g. for the design of wideband amplifiers. This report supplies the information for a number of our professional R.F. types.

## 2. METHOD OF DETERMINATION

The component values in the equivalent circuit diagram have been determined by means of a computer program.

This program needs the following input:

a. measured S-parameters at 3-5 frequencies.

b. Initial values for the circuit elements, which can be calculated from construction data and measured electrical characteristics.

The program calculates the S-parameters based on the initial values of the circuit elements.

Subsequently it changes the element values in a systematic way with the aim to reduce the maximum error to the minimum possible with the given circuit configuration.

The error is defined as:

$$E = \left| \frac{S_m - S_c}{S_m} \right| * 100\%,$$

in which $S_m$ is a measured S-parameter and $S_c$ a calculated one.

## 3. RESULTS OF CALCULATIONS

The results of the process described in the previous section are summarized in Table I and the circuit configuration is given in Fig. 1.

The quantities $h_{FE}$ and $f_T$ have been calculated from the final values of the circuit elements.
The accuracy given in Table I is the maximum value of the error as described in the previous section for any S-parameter at any frequency within the specified frequency range.
Outside this range, especially at lower frequencies, the accuracy will not be much worse.

## 4. INFLUENCE OF OPERATING POINT

If operation at another combination of $V_{CE}$ and $I_C$ is desired the information presented can be used with the following modifications:

a) $C_{CB}$ and $C_{CE}$ must be adapted to the new $V_{CE}$ according to the published graph $C_C = f\ (V_{CB})$.

b) S is linearly proportional to $I_C$.

c) $R_{BE}$ and $C_{BE}$ vary in the normal way with $I_C$, however the published graphs of $h_{FE} = f\ (I_C)$ and $f_T = f\ (I_C)$ must be observed.

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| TYPE | BFR90 | BFR91 | BFR96 | BFQ33 | Unit |
|---|---|---|---|---|---|
| $V_{CE}$ | 10 | 5 | 10 | 5 | V |
| $I_C$ | 14 | 30 | 50 | 14 | mA |
| $R_{BO}$ | 4,9 | 0,61 | 1,95 | 3,9 | ohm |
| $R_{BI}$ | 36,3 | 12,6 | 1,16 | 32 | ohm |
| $R_{BE}$ | 136 | 63,3 | 36,5 | 285 | ohm |
| $R_E$ | 0,14 | 0,15 | 0,41 | 1,46 | ohm |
| $R_C$ | 24,8 | 7,32 | 5,37 | 6,6 | ohm |
| S | 0,41 | 0,82 | 1,83 | 0,58 | A/V |
| $C_{BE}$ | 7 | 16 | 51,5 | 6,95 | pF |
| $C_{CB}$ | 0,38 | 0,69 | 1,08 | 0,22 | pF |
| $C_{CE}$ | 0,057 | 0,06 | 0,068 | 0,022 | pF |
| $C_S$ | 0,19 | 0,18 | 0,06 | 0,43 | pF |
| $L_B$ | 1,15 | 1,83 | 1,89 | 0,44 | nH |
| $L_E$ | 1,25 | 1,65 | 1,64 | 0,25 | nH |
| $L_C$ | 1,04 | 0,12 | 0,43 | 0,96 | nH |
| $h_{FE}$ | 55,9 | 51,9 | 66,8 | 165 | - |
| $f_T$ *) | 9,32 | 8,16 | 5,66 | 13,3 | GHz |
| Freq. range | 0,2-1 | 0,2-1 | 0,2-1 | 1-2 | GHz |
| Accuracy | 9,5 | 10,1 | 5,7 | 6,45 | % |

TABLE I

*) This $f_T$ is defined as $\frac{S}{2\pi C_{BE}}$

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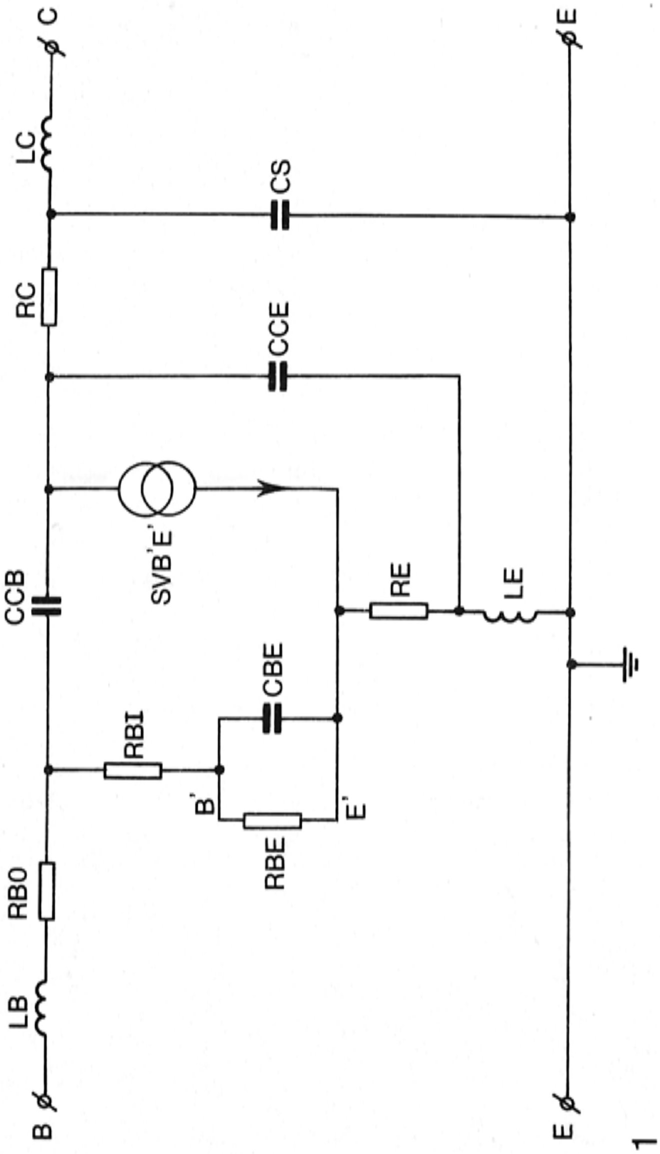

FIG. 1 Equivalent circuit diagram of bipolar transistor in common emitter connection.